

8.

Caudal Skeleton of Bermuda Shallow Water Fishes. V. Order Percomorphi: Carangidae.¹

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(Text-figures 1-20).

OUTLINE.	PAGE
roduction	31
ey	Opposite page 32
Bermuda Percomorphi	
Carangidae	
<i>Decapterus macarellus</i>	32
<i>Decapterus punctatus</i>	33
<i>Trachinotus palometa</i>	34
<i>Trachinotus goodei</i>	35
<i>Argyreus vomer</i>	37
<i>Trachurops crumenophthalma</i>	38
<i>Chloroscombrus chrysurus</i>	39
<i>Caranx ruber</i>	42
<i>Caranx bartholomaei</i>	42
<i>Caranx crysos</i>	43
<i>Caranx latus</i>	43
Summary	44

INTRODUCTION.

This is the fifth of a series of papers dealing with the caudal skeleton of Bermuda fishes. The Carangidae of Bermuda is represented by six genera and twelve species. No specimens are available of *Caranx guara*, considered uncommon in Bermuda, either in the collection of this department or in the collections of several other institutions. *Caranx guara*, locally known as "Gwelly," is seen by fishermen in shallow water but is said to be a shy, wary fish.

This paper deals principally with the adult fishes, as is the case with the four preceding studies of this series, but when young stages were available these were included.

The length of specimens in this paper is standard length unless otherwise stated.

For caudal fin terminology, general bibliography, and method of preparing specimens for this study, refer to Part I.

The symbols used in the figures are EP, epurial; HS, haemal spine; 1, 2, 3, 4, 5, hypurals; IS, interhaemal spine; INS, interneural spine; S, neural spine; UN, uroneural; UR, urostyle.

¹ Contribution No. 615, Department of Tropical Research, New York Zoological Society.

Contribution from the Bermuda Biological Station for Research, Inc.

We are indebted to the American Museum of Natural History for three specimens of *Argyreus vomer*. I take this opportunity to thank Dr. William Beebe, Director of this Department, and Mr. John Tee-Van, General Associate, for their cooperation.

The drawings are by Miss Janet B. Wilson, who kindly volunteered to do this work.

In Bermuda Carangidae several precaudal vertebrae are neither typical trunk nor typical caudal in structure. In all species these vertebrae have ribs (although in several specimens diminutive), which is characteristic of the typical trunk vertebrae. Closed haemal arches are also present, a typically caudal character. These precaudals include several modified vertebrae which immediately precede the true caudal.

The structure of the precaudal haemal arch in *Trachurops* differs radically from that of *Chloroscombrus* and *Caranx* and is readily distinguished from these two latter species by the crescent-shaped arch.

In *Decapturus macarellus* and *Decapterus punctatus* several precaudals and anterior true caudals are crescent-shaped and arise on the anterior half of their centra. *Decapturus* is the only species in this study which has the anterior true caudal haemal processes crescent-shaped.

It is of interest to note that the Bermuda Synodontidae is also unlike the families studied in Parts I, II and IV in having several vertebrae in the precaudal region which deviate from the typical trunk and caudal forms. In Synodontidae there are present, between the trunk and caudal, vertebrae lacking ribs (ribs being characteristic of the trunk), and also lacking closed haemal arches with spines, this structure being characteristic of the caudal.

In Bermuda Carangidae there is also this deviation from what is generally designated typical trunk and typical caudal vertebrae. This difference is found in several precaudal haemals which

have closed arches typical of the caudal region but lack the haemal spine which is typical of the trunk. Because of these differences the term precaudal centra is used as in Synodontidae.

The key is based on characters of the adult. In this respect it is important to mention, as an example, that in the immature specimen of *Chloroscombrus chrysurus*, 6 mm., the difference in length of the three short posterior neural and haemal spines and the length of the preceding long pair of spines is not pronounced as it is in the adult. In the mature specimen both the difference in length and shape is conspicuous and is considered a key character.

1. *Decapterus macarellus* (Cuvier & Valenciennes).

(Text-figure 7).

Diagnostic Characters:

1 interneural and 1 interhaemal arising over the 4th vertebra anterior to the urostyle.

The horizontal length of this posterior interneural and interhaemal about one and a half times longer than the anterior oblique part.

Haemal base of first anterior caudal lunar-shaped.

Caudal interneurals and interhaemals more slender than in the other genera.

Third stout posterior neural and haemal spines dagger-shaped and extend obliquely over three quarters of the following vertebra.

Material Studied.

The following description is taken from one specimen caught in Bermuda, Cat. No. 9,139, KOH Cat. No. 604, length 140 mm.

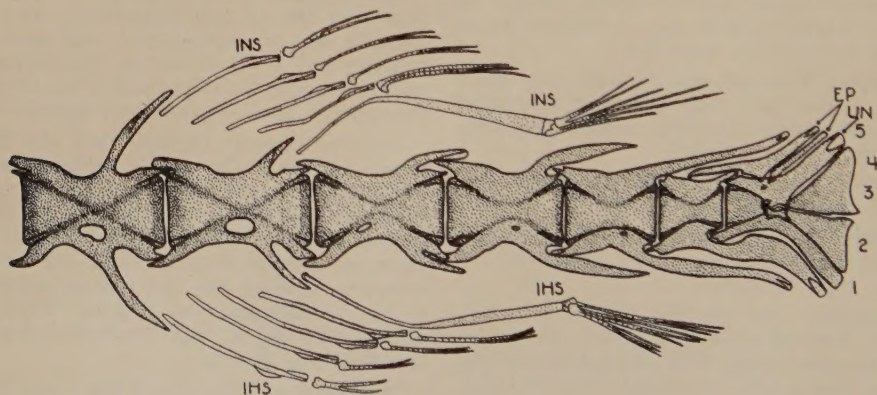
Caudal Osteology.

Urostyle: The urostyle is conical in shape. The posterior end appears to be consolidated on the dorsal surface with the base of the uroneurals and the fifth hypural and on the ventral with part of

the base of the first and second hypurals. The anterior part of the urostyle is identical in form and size with the adjacent posterior part of the penultimate centrum.

Uroneurals: There is one pair of uroneurals. These paired bones extend from the anterior margin of the urostyle to the distal margin of the hypural complex. On dissecting away the caudal rays the dorsal tip appears distinct from the tip end of the fifth hypural with which the uroneurals are fused. Text-figure 9 of a 10 mm. *Decapterus punctatus* shows the small fifth hypural in relation to the undeveloped uroneurals. Both these bones are only slightly ossified. Where young specimens of Carangidae were available for study this same relation of the two bones is found. Text-figures 13, 16, 17 and 18.

Hypurals: In this adult specimen there appear to be four hypural bones; two below and two above the median line. In the 10 mm. *Decapterus punctatus*, Text-figure 9, the large dorsal hypural is divided almost to the distal margin, indicating that in a slightly younger specimen this single bone of the adult is formed by two separate elements. This condition is found in several other young carangids. Text-figures 16, 17. The first and fifth hypurals are almost identical in size and are complimentary in their distal positions in the marginal complex. The two large median hypurals of the adult are completely separate to the anterior rounded ends which are partly covered by the base of the uroneurals and the projected lateral muscle attachment process of the first hypural. The fifth or dorsal-most hypural is recognized in the adult by the pointed tip adjacent to the end of the fourth hypural. For its entire length, with the exception of this tip, the fifth hypural is fused with the uroneurals and appears as one with these bones. Younger specimens give the true explanation of the development and relationship of the fifth hypural and the uroneurals. In the 42 mm. specimen of *Decapterus punctatus* the fifth hypural is more easily distinguished by the prominent line of junction which is still present between the hypural and the uroneurals.



Text-figure 7.

Decapterus macarellus. Tail of 140 mm. specimen showing especially the prolonged posterior interneural and interhaemal spines. $\times 3.52$.

Epurals: There are two epurals. The posterior one is slender and rod-like and slants obliquely forward and downward from the distal caudal margin to the dorsal edge of the uroneurals. The ventral tip is inserted between the two lateral uroneural bones. The anterior epural is wider than the ventral epural throughout the entire length. Anteriorly, a long finger-like projection tends forward and fills the area above the reduced neural process of the last centrum. Similar to the smaller epural, part of the ventral tip is inserted between the uroneural bones.

Additional Characters Worthy of Note: This is the only genus of Bermuda Carangidae which has extremely long and slender posterior interneural and interhaemal spines. The anterior and median ends arise near the anterior zygapophyses of the fourth vertebra from the urostyle and the bones extend back and toward the centra almost to the posterior margin of the next centrum. The interneurals and interhaemals, preceding the prolonged posterior pair, are more slender than the other species studied in this paper.

The precaudal haemal processes and also the first caudal haemals are lunar-shaped and placed at the anterior part of the centra. This development is similar to *Decapterus punctatus*.

2. *Decapterus punctatus* (Agassiz).

(Text-figures 8, 9).

Diagnostic Characters:

2 interneurals and 2 interhaemals arising over the 4th vertebra anterior to the urostyle.

The horizontal length of this posterior pair only a little longer than the anterior oblique part.

Haemal base of first anterior caudal lunar-shaped.

Caudal interneurals and interhaemals not as slender as those of *Decapterus macarellus*.

Dorsal and ventral fin rays not as slender as those of *Decapterus macarellus*.

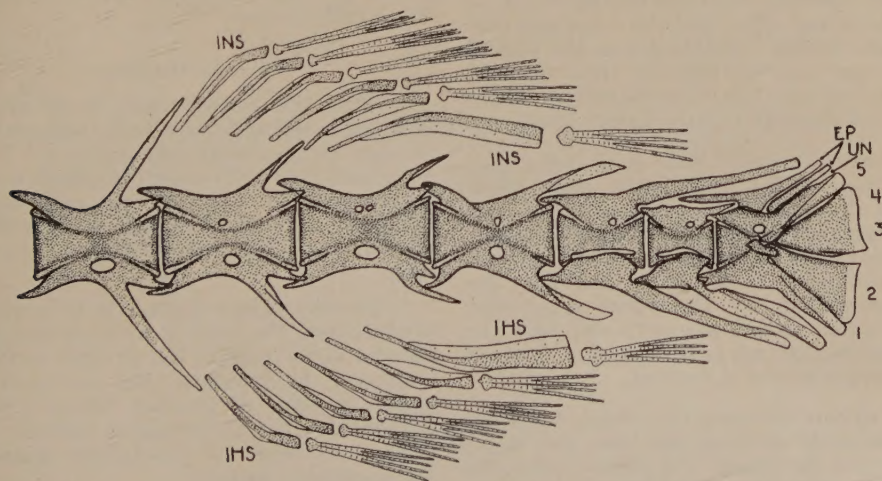
Material Studied.

The following description is taken from three specimens caught in Bermuda, Cat. No. 8,968, KOH Cat. No. 2316, length 10 mm.; KOH Cat. No. 340, length 18 mm.—taken from under a jellyfish; KOH Cat. No. 2315, length 42 mm.

Caudal Osteology.

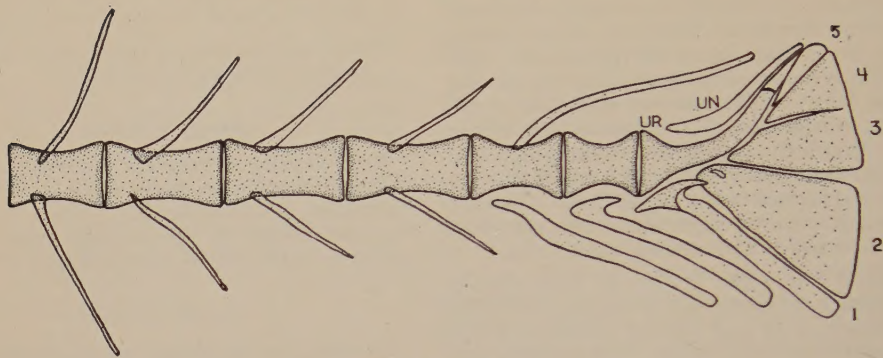
Urostyle: In the 42 mm. specimen the urostyle is conical in shape and similar to *Decapterus macarellus*. No definite posterior tip can be seen. In the 10 mm. specimen the upturned posterior end of the urostyle extends beyond the basal end of the fifth hypural. The anterior margin is identical in form with that of the preceding centrum but posteriorly the shape changes radically into a long slender upturned structure. The urostyle is slightly ossified as far as the base of the fifth hypural. Here, there is a heavy line across the urostyle and beyond this there is little ossification.

Uroneurals: As in *Decapterus macarellus*, there is a single pair of uroneurals and in the 42 mm. specimen these paired bones are similar in shape and position to those of the above species. In *Decapterus punctatus* the line of junction between the fifth hypural and the uroneurals is distinct but this has disappeared in the older specimen of the other species. In the 10 mm. *Decapterus punctatus* the uroneurals are long, slender, curved bones which extend from the hypural margin to the anterior part of the urostyle. Throughout their entire length the uroneurals are separate from the urostyle and the fifth hypural.



Text-figure 8.

***Decapterus punctatus*.** Tail of 42 mm. specimen showing the difference between this species and *Decapterus macarellus* in the arrangement and proportions of the interneural and interhaemal spines of the posterior groups. $\times 9.65$.



Text-figure 9.

***Decapterus punctatus*.** Tail of 10 mm. specimen. This stage shows the development of the 3rd and 4th hypurals which are fused in the 42 mm. specimen. The fifth hypural and the uro-neurals are separate bones in this stage. $\times 45.4$.

Hypurals: In the 42 mm. specimen there appears to be four hypurals; two below and two above the median line. In the 10 mm. specimen there are three hypural bones above the median line, which indicates that the large dorsal hypural of mature specimens is a combination of two bones. Also this young specimen has a small slit in the base of the second hypural which probably indicates a one-time ancestral division of this other large hypural bone. In all Bermuda *Isospondyli* and *Iniomi* there are at least three hypurals below the median line. In general shape and proportions the hypural complex of the adult *Decapterus punctatus* resembles that of *Decapterus macarellus*, with the exception of the identity of the fifth hypural and uro-neurals.

Epurals: There are two epurals in the adult, as in *Decapterus macarellus*, and the shape and proportions are similar. In this species the ventral ends are not inserted between the uro-neural bones, but this may be an age character. There is no trace of the epurals in the 10 mm. specimen.

Additional Characters Worthy of Note: The posterior pair of interneural and interhaemal spines are conspicuously longer than the preceding spines and the oblique part extends posteriorly for almost the length of the following centrum. This pair is not as long nor as slender as the corresponding pair of *Decapterus macarellus*. The precaudal haemal processes and also the first caudal haemals are lunar-shaped and placed on the anterior part of the centra.

In the 10 mm. specimen the caudal centra are only moderately spool-shaped and the zygapophyses and the neural and haemal processes are undeveloped. The neural and haemal processes are simple, slender bones and there is little differentiation in the development of the four anterior pair of spines. This difference is conspicuous in the adult.

3. *Trachinotus palometa* Regan.

(Text-figure 10).

Diagnostic Characters:

- 1 long and slender interneural and 1 interhaemal arising over the 4th vertebra anterior to the urostyle.
- 17 interneurals in the caudal region.
- Bases of haemal processes arising at the center of the centra.
- No short or stout posterior neural and haemal spines.

Material Studied.

The following description is taken from one specimen caught in Bermuda, KOH Cat. No. 601, length 119 mm.

Caudal Osteology.

Urostyle: The anterior part of the urostyle is identical in size and shape to the adjacent part of the preceding penultimate centrum. The posterior end cannot be seen because it is consolidated with the bases of the uro-neurals and hypurals. The dorsal surface is covered by the uro-neurals and the ventral surface by the hypural bases.

Uro-neurals: There appears to be a single pair of uro-neurals, the bones of which extend from the anterior dorsal edge of the urostyle to the distal margin of the hypurals. For part of the distal length the line of junction between the fifth hypural and the uro-neurals is distinct. In the smaller specimen of *Trachinotus goodei* the bones appear separate.

Hypurals: In this adult specimen there appear to be four hypural bones; two below and two above the median line. The second large hypural below the median line is solid with the exception

a small oblong hole near the base. In *Trachinotus goodei* of 54 mm. in length, the base is divided and a definite line can be seen which tends for half the length of the hypural bone. In the large dorsal hypural of *Trachinotus palometa* there is also indication that this hypural as at one time divided because a distinct line tends anteriorly from the distal margin for more than three-quarters of the length of the hypural. In the other species the base of this large dorsal hypural is divided and a narrow slit tends for about one-quarter the length of the bone and does not quite join with the slit extending from the distal margin. In the species under discussion the fifth or dorsal-most hypural is closely associated with the uroneurals but each can be identified at their dorsal extremity by distinct and separate pointed tips and a line which extends anteriorly for almost half the length. From here the two are fused. In the other species this fifth hypural is more distinct. Hypural numbers have been omitted from this illustration because of the inclusion of the caudal fin rays; for hypural reference, see Text-figure 11 of *Trachinotus goodei*.

Epurals: There are three epurals in this species and genus. The anterior or first epural is the largest, which is true of the adults of all the other species treated in this paper. Anteriorly, there is a broad thin growth which almost fills the entire area dorsal to the penultimate centrum and the urostyle. The second and third epurals are long, slender bones and very closely associated.

At both the proximal and distal ends the tips can be distinguished as separate bones. The ventral ends are not inserted between the uroneurals as is the case in *Trachinotus goodei*. Often this appears as a growth character but the specimen of this species is less than half the size of *Trachinotus palometa* and the tips of the former are inserted.

Additional Characters Worthy of Note: The illustration of this species is the only one which includes the caudal fin rays because the variation in the count is slight in the other species of Carangidae and therefore of little importance. Here the count is: dorsal raylets 6 plus 11 dorsal rays, and ventral raylets 6 plus 9 ventral rays, making a total of 17 dorsal plus 15 ventral.

4. *Trachinotus goodei* Jordan & Evermann.

(Text-figure 11).

Diagnostic Characters:

2 broad interneural and interhaemal spines arising over the 5th vertebra anterior to the urostyle.

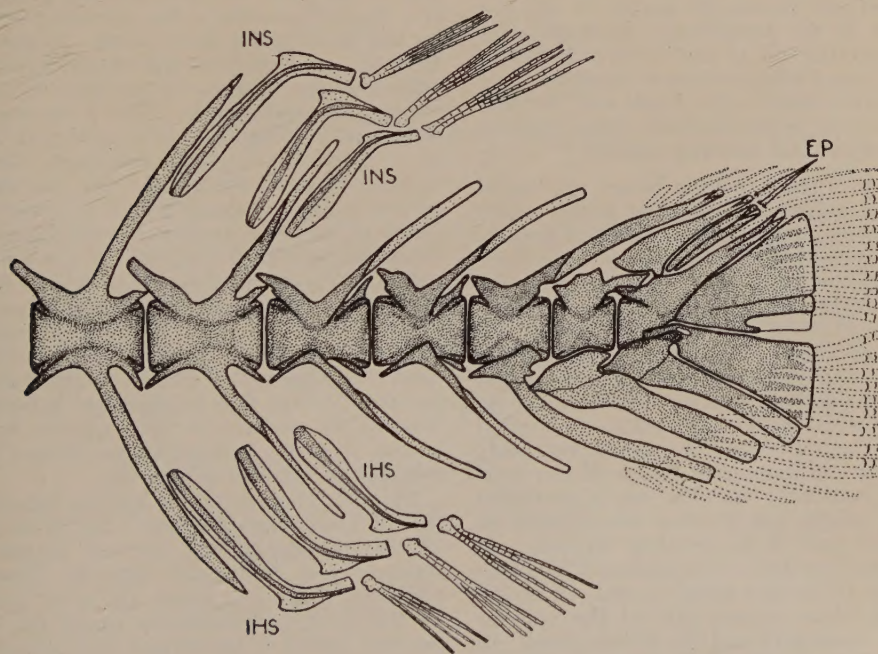
15 interneurals in the caudal region.

Bases of the haemal processes arising on the anterior half of the centra.

No short or stout posterior neural and haemal spines.

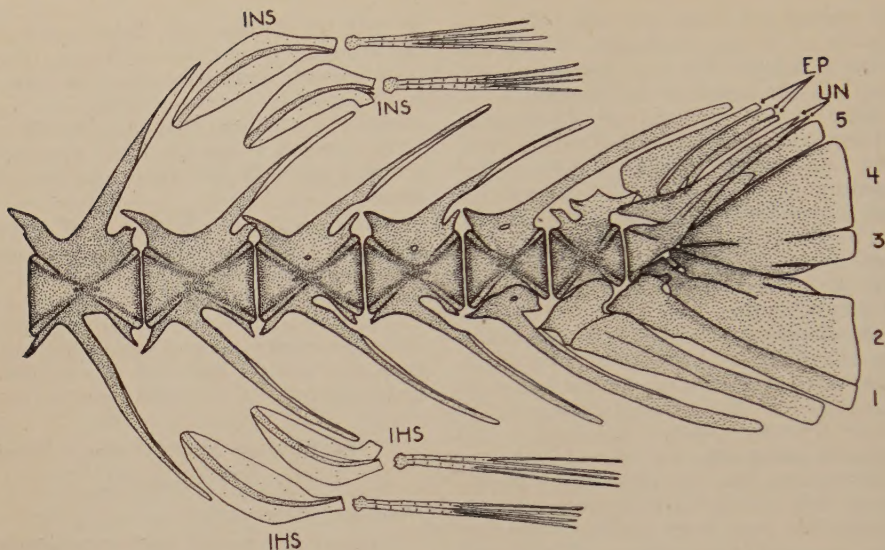
Material Studied.

The following description is taken from one



Text-figure 10.

Trachinotus palometa. Tail of 119 mm. specimen with three epurals. One interneural and one interhaemal spine is associated with the 4th vertebra from the urostyle. $\times 3.6$.



Text-figure 11.

Trachinotus goodei. Tail of 54 mm. specimen with three epurals and evidence of two pairs of uroneurals. Two interneurals and two interhaemals associated with the 5th vertebra from the urostyle. $\times 8.5$.

specimen caught in Bermuda, KOH Cat. No. 438, length 54 mm.

Caudal Osteology.

Urostyle: The anterior part of the urostyle is cone-shaped and its margin similar to the posterior part of the penultimate centrum. The reduced posterior tip of the urostyle is hidden and consolidated with the base of the uroneurals. The uroneurals protect the dorsal and posterior part of the urostyle and the bases of the hypurals about its ventral and posterior surface.

Uroneurals: These paired bones are unlike those of the other species studied in this paper. For a complete interpretation a series of younger specimens is needed. In this 54 mm. fish there are two pointed tips which form part of the hypural margin. Each represents paired lateral bones, the bases of which partly overlap the urostyle and the fifth hypural. The anterior dorsal uroneural extends from above the anterior margin of the urostyle where it is deep and wing-shaped and where bases of the epurals are inserted between its lateral bones. It extends posteriorly and dorsally and diminishes into a slender bone with a pointed distal tip. The second uroneural is similar distally but it arises immediately on the anterior part of the urostyle centrum. It overlaps the base and dorsal surface of the fifth hypural for all but the distal tip end. A broad, thin, paired bone covers part of the anterior half of the uroneurals and the fifth hypural. In our specimen of *Trachinotus palometa* of 119 mm. in length, only one pair of uroneurals can be found if the second pointed tip is to be interpreted as the fifth hypural. A series of young specimens is necessary in the case of both species to inter-

pret adequately the development of this part of the hypural complex.

Hypurals: There are two hypurals ventral and two dorsal to the median line. In the second large hypural there is definite evidence of a division of this bone, for there remains a suggestion of a double base with a line extending from here for half the length of the hypural. In none of the Bermuda carangids has this second hypural appeared as two separate bones, even in the very young of several species. This is the reason for consistently designating this particular hypural as a single bone. Its counterpart, the large hypural dorsal to the median line, has shown in several young specimens that it is formed by the fusion of two separate bones, which gives a criterion for calling this hypural three and four.

In this specimen hypurals three and four are distinct both anteriorly and posteriorly and only a small area in the center has fused beyond identity of the two separate bones. The fifth and most dorsal hypural is similar in size at its distal extremity to the first hypural and balances this bone in its position in the hypural fan. Its length, however, is less and the median end diminishes to a wedge-shaped tip.

Epurals: There are three epurals, which is also true of *Trachinotus palometa*. But in the species of this description the epurals appear more separate and individual than in *Trachinotus palometa*, which is a larger and older specimen. In this 54 mm. *Trachinotus goodei* the first or anterior epural is the largest, the second intermediate and the third, or posterior, the smallest. This is true of both their lengths and widths. The ventral ends are inserted between the lateral bones of the uroneurals. This is not so in the other species.

5. *Argyreiosus vomer* (Linnaeus).

(Text-figures 12, 13).

Diagnostic Characters:

The caudal skeleton is conspicuously deeper and relatively shorter than any of the other species treated.

3 anterior caudal haemal spines with triangular projections on the anterior surface at mid-length.

3 short posterior neural and haemal spines stout and club-like.

Material Studied.

This description is from a study of three specimens presented by the American Museum of Natural History. Cat. No. 14,184 from Pompano, Florida; KOH Cat. No. 2321, length 18 mm. Cat. No. 12,505 from Mastic, L. I.; KOH Cat. No. 2322, length 45 mm. Cat. No. 13,583 from Rio de Janeiro; KOH Cat. No. 2323, length 40 mm.

Caudal Osteology.

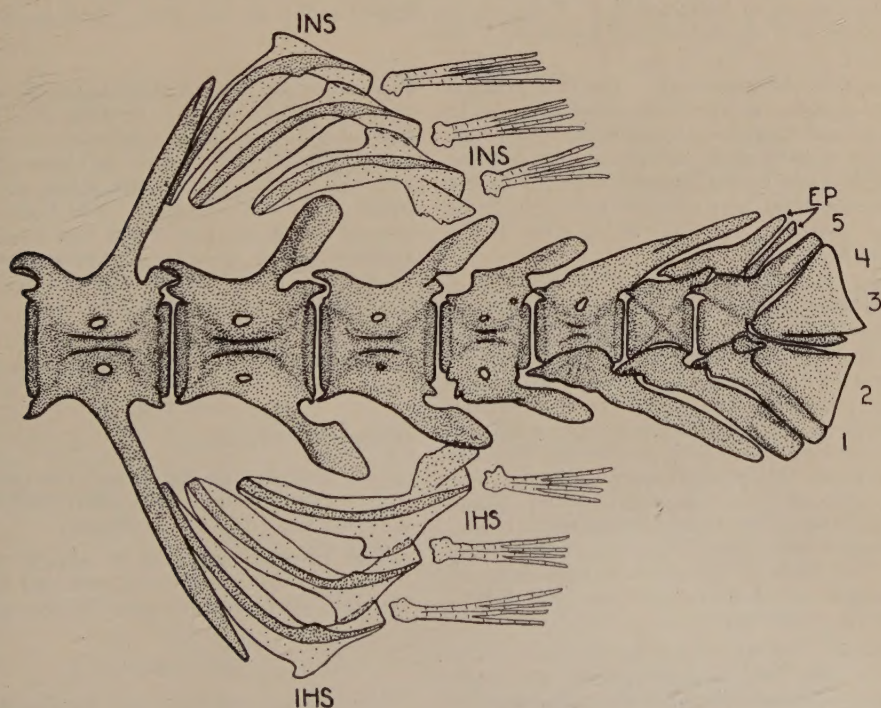
Urostyle: In the adult specimen of 140 mm. in length the posterior end of the urostyle is consolidated with the dorsal bones and cannot be distinguished.

In our young specimen of 18 mm. the urostyle extends dorsally to the hypural margin. Anteriorly, the urostyle is almost a perfect half

centrum but at the base of the second hypural it turns abruptly and extends in an oblique-dorsal direction and becomes a slender tapering rod. At the basal tip of the fifth hypural a mark appears which indicates consolidation in this youthful stage of the urostyle. The bases of all of the hypurals are separate from the urostyle with the exception of the fifth hypural whose anterior surface is in conjunction with the urostyle.

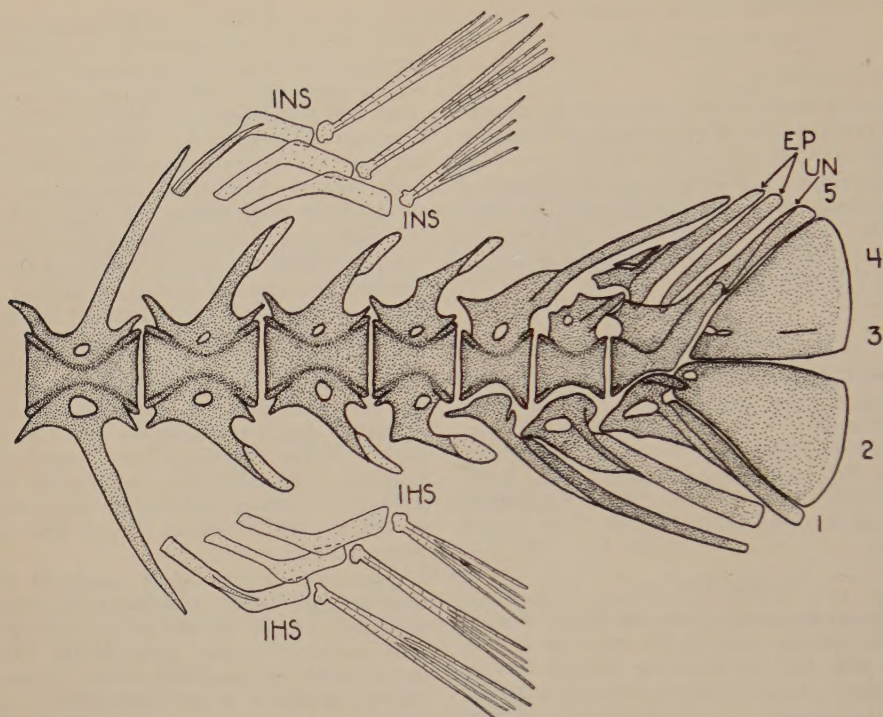
Uroneurals: There is a single pair of uroneurals which are more distinct in the 18 mm. specimen than in the two older stages. In the smallest fish the anterior part is already enlarged and fills the area dorsal to the urostyle but the spool-shaped urostyle is distinct. In the largest specimen the urostyle and the uroneurals have become one and there is only a suggestion of the urostyle as such. Both the anterior and the posterior portion of the uroneurals have increased in proportions. Distally, the uroneurals and fifth hypural have fused and there is only a suggestion of the hypural which in the 18 mm. specimen was a distinct bone.

Hypurals: In the adult specimen there are four hypural bones, two below and two above the median line. In the 18 mm. fish it is clear that the large hypural dorsal to the median line is the result of the fusion of two bones. Truly young specimens would undoubtedly show this as they have in several other species in this paper. The dorsal, or fifth hypural, is distinct in the 18 mm. specimen but in the 140 mm. fish it has be-



Text-figure 12.

Argyreiosus vomer. Tail of 140 mm. specimen. The bones of this deep-bodied fish are conspicuously stout and the centra less elongate than in the other species. $\times 3.23$.



Text-figure 13.

Argyreiosus vomer. Tail of 18 mm. specimen showing the posterior end of the urostyle, the uroneurals and the fifth hypural. These are not distinct in the 140 mm. fish. There is a hint of the division of the 3rd and 4th hypurals. $\times 25.2$.

come one with the uroneurals. The first hypural is not as massive as the corresponding bone in the adult, and there is a conspicuous large hole in the base or arch area. This is present in most of the neural and haemal bases but in the largest specimen the holes have disappeared in the three posterior processes and become smaller in the preceding arch bases.

Epurals: There are two epurals. In the 18 mm. specimen their shape in general is similar with the exception of the anterior projection on the first bone, which is a growth character. In no respect do these two bones resemble one another in the 140 mm. specimen. The anterior projection from the base of the first epural has become solid and massive and fills the area above the reduced neural process of the penultimate centrum. The rod-like form of the young specimen has disappeared entirely. The second or posterior epural has changed very little from that of the young stage. The ventral ends of both epurals in all three stages are inserted between the lateral bones of the uroneurals.

Additional Characters Worthy of Note: As is typical of this deep bodied species, the interneural and interhaemal spines are massive in the adult specimen. In each there is a central shaft which is heavily ossified and has lateral projections on the horizontal part. In the smallest specimen there is the beginning development of

this projection and all other parts of these bones are only slightly ossified. Several anterior caudal haemal spines are unique in development as compared with the other Bermuda Carangidae. The first and second are usually stout and at mid-length their surfaces abut. The three following haemal spines are also stout and have on their anterior sides heavy triangular projections. These are present in all three stages. This is illustrated in the Key (Text-fig. 5).

6. *Trachurops crumenophthalma* (Bloch).

(Text-figure 14).

Diagnostic Characters:

The posterior group of two interneurals and two interhaemals associated with the fourth vertebra from the urostyle.

The haemal processes of several precaudal centra are crescent-shaped and the spines arise on the anterior half of the centra.

Material Studied.

Three specimens were used for this description and all were caught in Bermuda. Cat. No. 9,140 KOH Cat. No. 615. Cat. No. 9,140, KOH Cat. No. 614, length 115 mm. Cat. No. 25,147, KOH Cat. No. 1135, length 108 mm.

Caudal Osteology.

Urostyle: In all specimens studied the posterior end of the urostyle is embedded in the terminal centra. The bases of the uroneurals and the hypurals surround this area. The anterior part of the urostyle is almost a perfect half centrum in shape and size. The dorsal surface is covered by the heavy uroneurals and the ventral surface by the base of the first hypural.

Uroneurals: There appears to be but a single pair of uroneurals. In our adult specimens these paired bones are massive and extend obliquely backward and dorsally from above the anterior part of the urostyle to the distal margin of the hypurals. In the anterior area a small portion of the ventral ends of the epurals are wedged between the lateral bones of the uroneurals. The oblique distal part probably represents the fifth hypural fused with the uroneurals. Our material is too advanced in development to illustrate this detail, which is found in the young specimens of the closely related genera.

Hypurals: Our material shows two hypurals ventral to and two dorsal to the median line. The central bones are large and fan-shaped, which is characteristic of this family. Young specimens could undoubtedly show that the large dorsal hypural was formed by the fusion of two bones and also that the fifth hypural was separate. In these adult specimens the fifth hypural is fused with the uroneurals and not distinguishable from them. On the basis of repeated evidence in the young of several closely related genera the hypurals are considered as five, which is seen in the text-figure 14.

Epurals: The two epurals fill the area above the penultimate centrum and the urostyle. The long projection of the first epural extends anteriorly above the reduced neural process of the penultimate centrum. The base is inserted between the uroneurals. The second or posterior

epural is long and slender and slightly enlarged at the ventral end, which lies between the uroneurals.

7. *Chloroscombrus chrysurus* (Linnaeus).

(Text-figures 15-18).

Diagnostic Characters:

26 or 27 interhaemals in the caudal region.

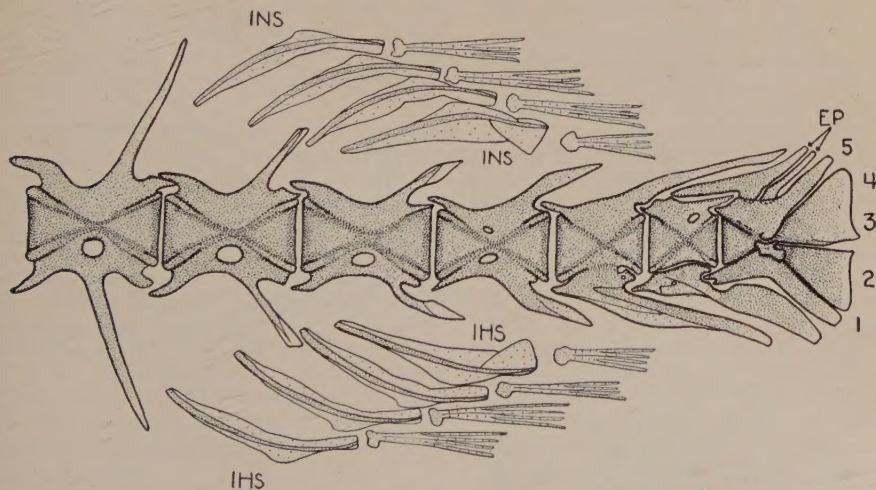
6 interhaemals between the first and second anterior caudal haemal spines.

Material Studied.

The following description is based on seven specimens taken in Haiti. Cat. No. 6,842, KOH Cat. No. 2317, lengths 100 mm. and 80 mm. Cat. No. 7,183, KOH Cat. No. 2318, lengths 15, 10, 7.5, 6.5, 6 mm.

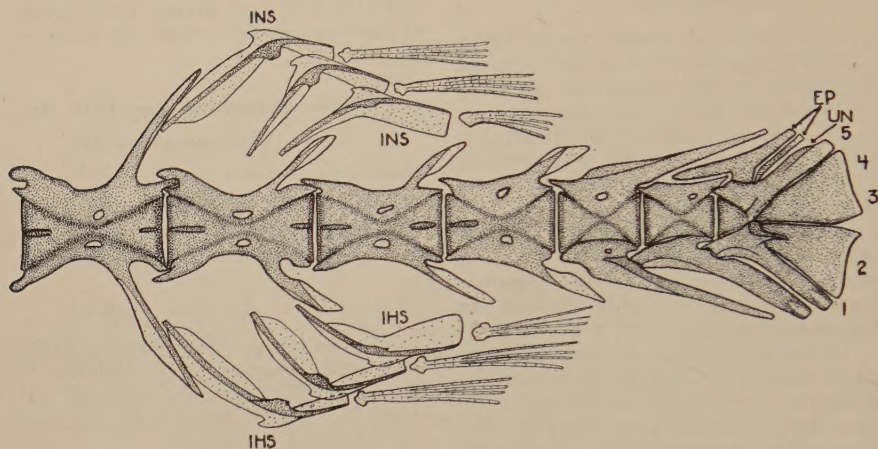
Caudal Osteology.

Urostyle: Four stages of development were found in specimens of 6 mm., 10 mm., 15 mm., and 100 mm. in length. In the largest fish, which is fully ossified, the posterior end of the urostyle is completely hidden by the overlapping uroneurals and hypurals. As in the other Bermuda Carangidae the anterior part of the urostyle is almost a complete half centrum and is similar in proportions to the adjacent part of the preceding centrum. In the 6 mm. specimen the urostyle is a long, slender, rod-like structure which extends from the posterior margin of the penultimate centrum to the distal margin of the hypurals. Anteriorly, the proportions are similar to the adjacent part of the preceding centrum. The urostyle extends posteriorly in an oblique and dorsal direction, tapering to about one-half the depth. The ossification is delicate throughout and ends midway between the bases of the fourth and fifth hypurals. A cartilaginous rod



Text-figure 14.

Trachurops crumenophthalma. Tail of 115 mm. specimen showing two interneurals and two interhaemals associated with the 4th and 5th vertebrae from the urostyle. $\times 11.65$.



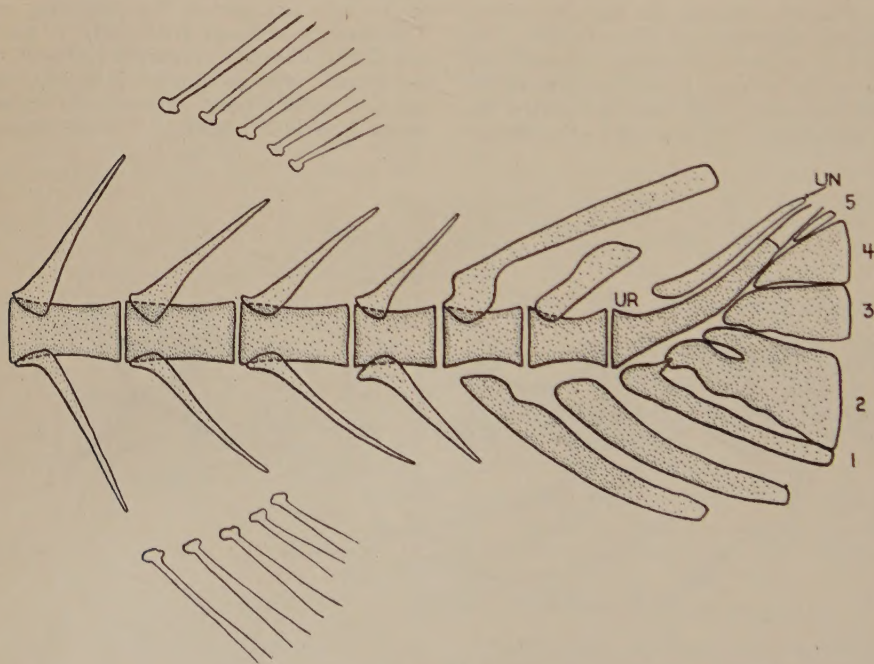
Text-figure 15.

***Chloroscombrus chrysurus*.** Tail of 100 mm. specimen showing the 3rd and 4th hypurals fused and the 5th hypural united with the uroneurals. $\times 33.3$.

extends from here and disappears in the bases of the caudal rays. In the 10 mm. specimen ossification is more pronounced and the posterior dorsal end is seen at the center of the base of the fourth hypural. Anteriorly, the shape has begun to resemble that of the adult. The 15 mm. specimen shows still greater ossification and consolidation.

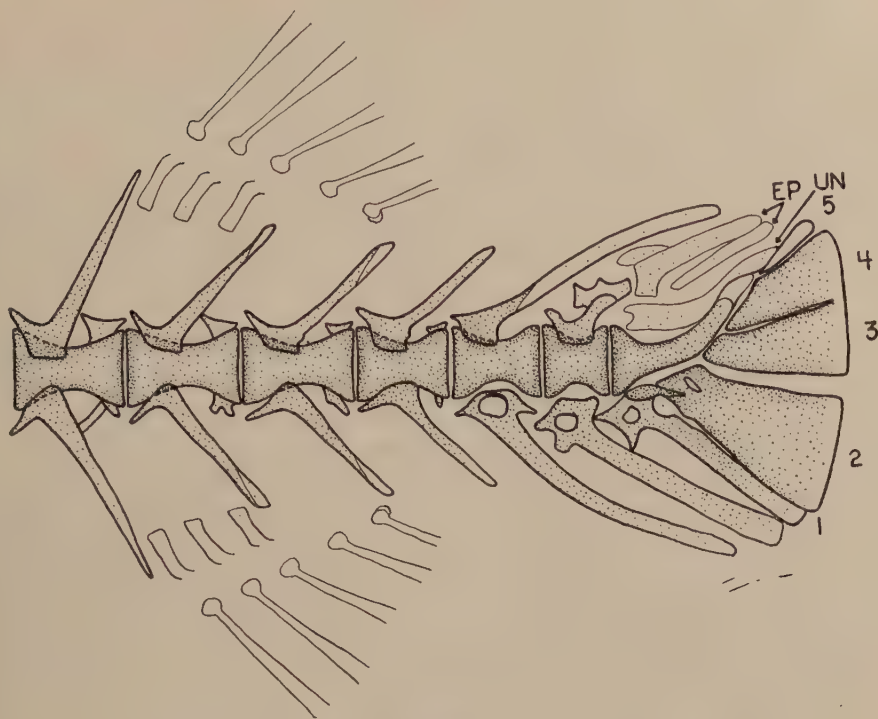
Uroneurals: There is a single pair of uroneurals, which in the adult is indicated only at the distal end. These bones have become fused with the

fifth hypural in the largest specimen. The three younger stages show clearly the development of the uroneurals. In the 6 mm. specimen this paired bone extends dorsally above the urostyl from the region of the second hypural to the margin of the hypurals. It is long and slender and the anterior end is slightly larger than the posterior tip. It is of importance to note the relation of this bone to the others and its independent position, which is found only in the very young stages.



Text-figure 16.

***Chloroscombrus chrysurus*.** Tail of 6 mm. specimen which is partly ossified. There are no interneurals or interhaemals or epurals. The 3rd, 4th and 5th hypurals and the uroneurals are separate bones. The urostyle extends into the hypural margin. $\times 104$.



Text-figure 17.

***Chloroscombrus chrysurus*.** Tail of 10 mm. specimen showing increased ossification. The centra are spool-shaped and the epurals, uroneurals and base of the interneural and interhaemal spines have appeared. The 3rd and 4th hypurals have begun to fuse and the uroneurals about the fifth hypural. $\times 83$.

In the 10 mm. specimen the uroneurals have increased anteriorly both in depth and length and almost reach the anterior margin of the urostyle. The shape of this end has changed from a blunt rounded tip to a deeper indented form. The posterior part is reduced and the distal end appears in conjunction with almost half the proximal length of the fifth hypural. In this region the uroneurals have grown over the urostyle. The anterior part is still separate from the urostyle.

In the 15 mm. specimen the uroneurals resemble the structure of the adult more than the 10 mm. specimen, and the shape and proportions are similar. The base of the uroneurals has fused with the dorsal surface of the urostyle and in only one place is there any indication of the youthful stage where all the under part of this bone was entirely separate. There still remains two perforations or unossified areas. The anterior part of the uroneurals about the reduced neural process of the penultimate centrum and extend dorsally almost to the distal margin of the fifth hypural. In this stage the uroneurals have become entirely consolidated with the dorsal surface of this fifth hypural.

Hypurals: In the adult 100 mm. specimen there are two hypurals below and two above the median line. The first and fifth hypurals are the same size distally and flank the ventral and dorsal

part of the hypural fan. Two large hypurals form the central part of the hypural complex; one below and one above the median line. From a study of the young specimens it is certain that the large dorsal hypural is formed by the fusion of two bones and that the fifth hypural has fused with the uroneurals.

In the 6 mm. specimen, which is the youngest stage available for study of the Bermuda Carangidae, there are five distinct hypural bones. The first, or anterior bone, is long and slender and slightly enlarged at the median base. This base, which is the haemal arch, develops rapidly in the 10 mm. and 15 mm. stages. In the smaller fish a square, wing-like growth projects anteriorly and abuts the haemal process of the preceding centrum and there is a large hole or unossified area in the center of this growth. In this stage the lateral ridge, for the muscle attachment, is a small triangular projection from the base and overlaps slightly the base of the second hypural. In the 10 mm. specimen this ridge has more than doubled in size and proportion.

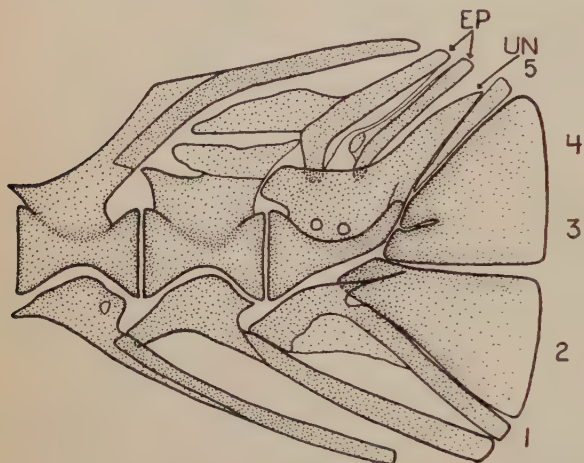
The first hypural of the 15 mm. specimen resembles the corresponding bone of the adult fish with the exception of the density of ossification, and extent of development of the muscle attachment process, and proximity to the ventral surface of the urostyle. There is still considerable space between the haemal arch and the urostyle,

which entirely disappears in the adult specimen. This is also true of the preceding haemal arches.

The second hypural changes less in shape and proportions than any of the other hypural bones. In the 6 mm. specimen the base is divided into two by a long oval slit which extends for about one-quarter the length of the bone. In the 10 mm. specimen the two bases have fused but a small oval hole remains. In the 15 mm. fish there is no indication of either the two bases or the slit of the younger stages. The third and

form part of the caudal margin. In the 15 mm. specimen the degree of ossification is identical with the other caudal bones. The shape of both epurals is similar to that of the adult, and the median ends are inserted between the uroneurals which is also an adult character.

Additional Characters Worthy of Note: The illustrations show the increase in ossification with age and also the change in shape and proportions of all of the caudal bones. In the 6 mm. specimen there is no evidence of epurals, inter-



Text-figure 18.

***Chloroscombrus chrysurus*.** Tail of 15 mm. specimen. The posterior end of the urostyle is reduced and the distal portion of the uroneurals flank the side of the 5th hypural. In the 100 mm. specimen these two bones have fused. $\times 42$.

fourth hypurals are separate bones in the youngest stage and in the 10 mm. specimen their distal margin has fused and the space between become less. The 15 mm. fish still has two bases which represent the two separate bones of the younger stage but the slit between has diminished by more than half its former length. In the 100 mm. specimen there is no trace of a slit or double base. The fifth hypural appears as a very small wedge-shaped bone between the distal end of the urostyle and the fourth hypural. Its growth and development from this stage to the adult is remarkable and without several very young specimens this hypural would not be identified as an hypural bone. In the youngest stage this bone is entirely separate from the surrounding structures. In the 10 mm. fish the bone has increased in length and depth and about one-half of its anterior length abuts the uroneurals on the dorsal surface. In the 15 mm. specimen the length is greatly increased and all but a small part of the dorsal end is in conjunction with the uroneurals. The adult specimen of 100 mm. shows that the fifth hypural and the uroneurals have fused and all that remains of their separate identity is a light line at the distal extremity.

Epurals: There are two epurals in this species. Neither of these bones can be found in the 6 mm. fish. In the 10 mm. specimen these epurals appear with delicate ossification and as long slender bones. The anterior epural is longer and broader than the second one and has the beginning of the anterior projection near the median end. Both bones are free and their distal tips

neurals and interhaemals. The centra are rectangular in shape with considerable distance between their margins. In the 10 mm. specimen the spool-shape of the centra begins to change and to resemble the adult. The epurals are lightly ossified and also the interneurals and interhaemals. The zygapophyses are present on the dorsal and ventral surfaces of the centra. With the consolidation from a long rectangular structure to a shorter spool-shaped centra the neural and haemal processes appear to shift from their youthful anterior position to a central position. The three reduced posterior neural and haemal spines of the adult are simple and unmodified in the 6 mm. and 10 mm. specimens.

8. *Caranx ruber* (Bloch).

(Text-figure 19).

9. *Caranx bartholomaei* Cuvier & Valenciennes

Diagnostic Characters (both species):

Total of 24 interhaemals in the caudal region.

Total of 22 interneurals in the caudal region.

4 interhaemals between the first and second anterior caudal haemal spines.

3 interneurals and 3 interhaemals in posterior group in three specimens. The oblique part more slender than in the two following species.

Minor species differences cited in Key and in text.

Material Studied.

Caranx ruber; one specimen taken in Haiti. t. No. 7,016, KOH Cat. No. 2320, length 160 mm.

Caranx bartholomaei; two specimens caught in Bermuda. Cat. No. 25,057, KOH Cat. No. 1074, length 50 mm. Cat. No. 25,065, KOH Cat. No. 73, length 52 mm.

Caudal Osteology.

Urostyle: The reduced terminal end is hidden in both species by the heavy uroneurals on the dorsal and the base of the hypurals on the ventral surface. No small specimens are available to show the development. The anterior part is T-shaped and of the same proportions as the posterior half of the penultimate centrum. The dorsal surface is covered by the uroneurals and the ventral by the first hypural in *Caranx ruber* (Text-fig. 19). In *Caranx bartholomaei*, which is one-third the length, the base of the first hypural is still separate from the ventral surface of the urostyle.

Uroneurals: In the 50 mm. specimen of *Caranx bartholomaei* there is indication of one pair of uroneurals. At the distal end the line of junction between the uroneurals and the fifth hypural still remains. There is no evidence of this in the 160 mm. specimen of *Caranx ruber*. In this species the two bones have fused.

Hypurals: In both species there are two hypurals which are ventral to and dorsal to the median line. Their positions and proportions are similar in the corresponding bones. Because of facts presented by several young stages in closely related genera in this family, the hypural bones of these species are numbered 1 to 5 in the illustration.

Epurals: There are two epurals in both species and the corresponding bones are similar in shape

and position. In the distal dorsal portion of the smaller *Caranx bartholomaei* the epurals are more slender. This has been found to be an age character in other genera.

Additional Characters Worthy of Note: In *Caranx ruber* the posterior neural zygapophyses have hook-like projections on the dorsal surface. This is shown in the anterior vertebra in the illustration. The development is especially prominent in the central caudal area. In *Caranx bartholomaei* the dorsal surfaces of the corresponding zygapophyses are smooth. There is also a difference in the development of the anterior neural zygapophyses of the two species. In *Caranx ruber* the surfaces are jagged and notched, especially in the central caudal area, but this is not true in *Caranx bartholomaei*. In a detailed study of the two species many minor differences such as these distinguish each as a different species.

10. *Caranx crysos* (Mitchill).11. *Caranx latus* Agassiz.

(Text-figure 20).

Diagnostic Characters (both species):

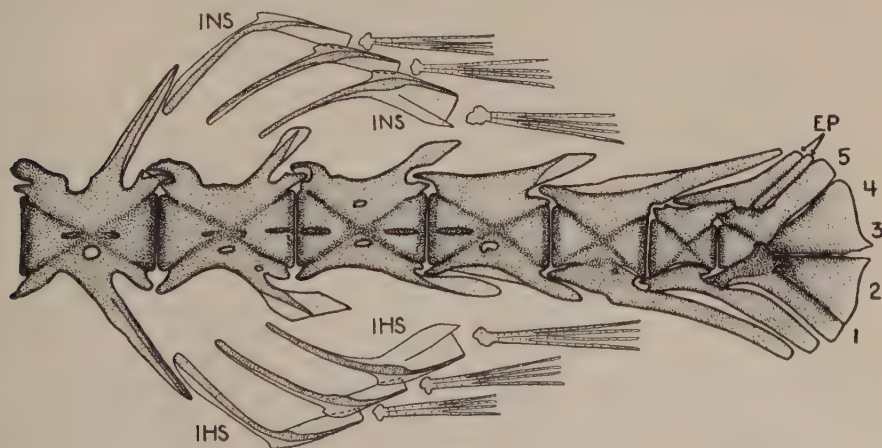
Total of 17 to 20 interhaemals in the caudal region.

Total of 15 to 18 interneurals in the caudal region.

3 interhaemals between the first and second anterior caudal haemal spines.

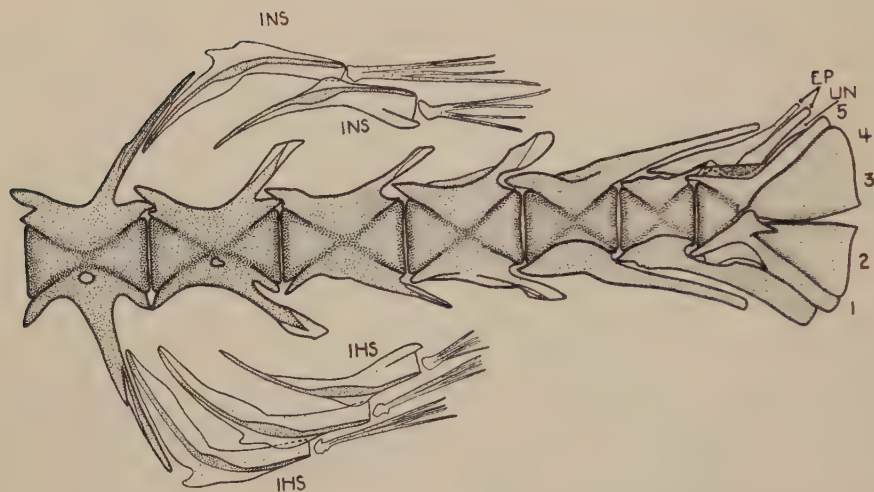
2 interneurals and 2 or 3 interhaemals in the posterior group in the five specimens studied. The oblique part broader than in the two preceding species.

Minor species differences are cited in the Key and in the text.



Text-figure 19.

Caranx ruber. Tail of 160 mm. specimen. This figure represents both this species and *Caranx bartholomaei* which in gross structure are similar. $\times 2.74$.



Text-figure 20.

Caranx latus. Tail of 87 mm. specimen. This figure represents both this species and *Caranx crysos*, the gross structure being similar. $\times 15.87$.

Material Studied.

Caranx crysos; one specimen taken in Haiti. KOH Cat. No. 2319, length 130 mm.

Caranx latus; four specimens caught in Bermuda. KOH Cat. No. 1070, length 44 mm. KOH Cat. No. 412, length 63 mm. KOH Cat. No. 649, length 80 mm. KOH Cat. No. 1040, length 87 mm.

Caudal Osteology.

Urostyle: The anterior part of the urostyle in both species is cone-shaped and almost identical in shape with the posterior half of the preceding centrum. The dorsal surface is fused with the bases of the uroneurals and the ventral surface with the base of the first hypural. The posterior end cannot be distinguished in specimens as old as those in this collection. Text-figure 20 represents both species.

Uroneurals: In the 87 mm. specimen of *Caranx latus* one pair of uroneurals is found where it has fused during growth with the fifth hypural. In *Caranx crysos*, which is 130 mm. in length, there is no evidence left and the fifth hypural and uroneurals appear as one structure.

Hypurals: In both species there are two hypurals below and two above the median line. They are similar in proportions and arrangement to the other species of *Caranx*. None of these specimens are young enough to show the development and eventual fusion of the hypurals but the figure is numbered to show the position of five hypurals which the young of closely related genera have demonstrated.

Epurals: There are two epurals, as in all but one genus of Carangidae. In the distal portion of the smaller *Caranx latus* these bones are more slender than those of *Caranx crysos*. This development is correlated with age in other genera.

Additional Characters Worthy of Note: In *Caranx crysos* there are 20 interhaemals in the caudal region and 18 interneurals. There are fewer in *Caranx latus*, which has 17 interhaemals and 15 or 16 interneurals in the caudal region. The shapes and proportions of the zygapophyses differ in the two species, also the presence and absence of neural and haemal arch perforations. In a detailed study of the minor differences in both species these can be distinguished as two separate species.

SUMMARY.

The following facts correlate the salient similarities found in the study of Bermuda Carangidae.

Vertebral count: 10 trunk plus 14 caudal in all species but *Caranx crysos* and *Decapterus punctatus*. These have 10 trunk and 15 caudal. In both, only one specimen was available for the count.

Caudal fin count: There is only slight variation among the species. The illustration of *Trachinotus palometa* (Text-fig. 10) shows the arrangement. It is usually 6 raylets plus 11 rays dorsal; 6 raylets plus 9 rays ventral, making a total of 17 dorsal, plus 15 ventral.

Epurals: There are two epurals in all but the genus *Trachinotus*, which has three.

Hypurals: In the adults of all species there are four hypurals; two below and two above the median line. The two central bones are large and fan-shaped. The dorsal or fifth hypural is fused with the uroneurals in all adults. In the young stages it is separate. In young stages the large dorsal hypural is found to be formed by the fusion of two separate bones. There remains a hint in several of the young of a one-time division of the large ventral or second hypural. This is not complete in any specimens of this

family. In all Bermuda Isospondyli and Iniomi there are at least three hypurals below the median line.

Uroneurals: In all species but *Trachinotus* *codei* there is a single pair of uroneurals. Here there is a suggestion of a second pair, but young specimens are necessary to ascertain this fact.

Elongate spines in caudal complex: In the adult of all species one long neural spine and two long stout haemal spines form the anterior part of the caudal complex.

Anterior caudal haemals: *Decapterus* is the only genus in this series which has the bases of

the first few anterior caudal haemals crescent-shaped and situated on the anterior half of the centra. The typical shape is triangular.

Pre-caudal haemals: *Decapterus* and *Trachurops* have crescent-shaped precaudal haemal bases which are situated on the anterior half of the centra.

Specialized neural process: Adult specimens of all species of Bermuda Carangidae have a reduced neural process on the penultimate centrum. The long anterior projection from the first epural extends into the area above this process.

KEY TO CAUDAL SKELETON OF BERMUDA SHALLOW WATER CARANGID FISHES.

(Text-figs. 1-6).

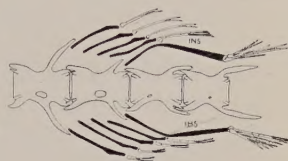
Decapterus macarellus

1 interneural and 1 interhaemal arising over the 4th vertebra anterior to the urostyle. The horizontal part about one and a half times longer than the anterior oblique part.

Sub-Group A

Horizontal length of posterior interneural and interhaemal conspicuously longer than the preceding spines.

1st anterior caudal haemal arch crescent-shaped and on anterior half of centrum.



Text-figure 3.

Decapterus punctatus

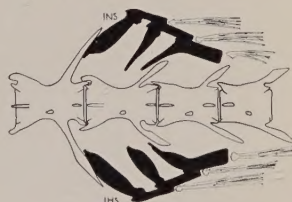
2 interneurals and 2 interhaemals arising over the 4th vertebra anterior to the urostyle.

The horizontal part only a little longer than the oblique part.

Sub-Group B

Horizontal length of posterior interneural and interhaemal not conspicuously long and the general shape the same as the spines immediately preceding.

1st anterior caudal haemal arch not crescent-shaped and on entire centrum.



Text-figure 4.

Trachinotus palometa

1 interneural and interhaemal spine over the 4th vertebra from the urostyle. 17 interneurals in caudal region.

Trachinotus goodei

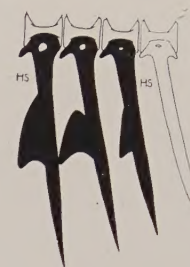
2 interneural and interhaemal spines over the 5th vertebra from the urostyle. 15 interneurals in caudal region.

Division I

Argyreus vomer

3 anterior caudal haemal spines with triangular projections at mid-length.

Posterior vertebrae relatively shorter and more massive than in Division II.



Text-figure 5.

Sub-Division A

Trachurops crumenophthalma

Posterior group of interneurals and interhaemals associated with 4th vertebra from the urostyle.

Precaudal haemal process crescent-shaped and on anterior half of centrum.

Division II

No triangular projections on anterior caudal haemals.

Posterior vertebrae relatively longer and more slender than in Division I.



Text-figure 6.

Group I

Chloroscombrus chrysurus

26 or 27 interhaemals.

6 interhaemals between the first and second anterior caudal haemal spines.

Sub-Division B

Posterior group of interneurals and interhaemals associated with 5th vertebra from the urostyle.

Precaudal haemal process triangular-shaped and covers all of centrum.

Group II *Caranx*.....

Less than 26 interhaemals.

3 or 4 interhaemals between the first and second anterior caudal haemal spines.

Caranx ruber

Posterior neural like project especially in Anterior neural dorsal surface caudal region.

Sub-Group A

24 interhaemals and 20 caudal region.

4 interhaemals between anterior caudal haemal spines.

Caranx bartholomae

No hook-like process of posterior Anterior neural dorsal surface.

Caranx crysos

20 interhaemals caudal region.

Sub-Group B

17 to 20 interhaemals and neurals in caudal region.

3 interhaemals between anterior caudal spines.

Caranx latus

17 interhaemals caudal region.

GROUP I

3 posterior neural and haemal caudal spines conspicuously short or stout. 2 epurals.



Text-figure 1.

GROUP II

No conspicuously short or stout posterior neural and haemal caudal spines. 3 epurals.



Text-figure 2.

